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Rp23745

ISSN 0710-7951

NANTICOKE WATER CHEMISTRY
1979

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January 1981

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SUMMARY

During the ice-free season of 1979, near-surface water samples were collected 12 times from five stations near Nanticoke in Lake Erie and analyzed for a wide range of physical and chemical water quality parameters. No parameter exceeded its Ontario water quality objective for protection of aquatic life. Two-way analysis of variance showed that levels of 89% of the parameters varied significantly with time and that levels of 42% of the parameters varied significantly in space. The Kruskal-Wallis test showed that 32% of the parameters varied in space. Past reports of Nanticoke water chemistry stated that 27% of the parameters tested by two-way analysis of variance varied significantly in space. Storms, upwelling, or biological activity, which might affect water chemistry differently at different stations, might limit the applicability of two-way analysis of variance as a tool for analyzing these data.

INTRODUCTION

The 1979 ice-free season was the eleventh of uninterrupted water chemistry monitoring in the Nanticoke area of Lake Erie. The purpose of the 1979 program was to continue monitoring the parameters studied in the past; however, fewer stations were sampled. This is a report of the 1979 data and of the results of statistical analysis of those data. Implications of these results for the environment of Nanticoke will be discussed in a Nanticoke Integrated Report, which the Ministry of the Environment (MOE) and the Ministry of Natural Resources are preparing.

SURVEY OPERATION

Five stations were sampled in 1979: 501, 810, 1040, 1085, and 1087 (Figure 1). All stations were sampled on 12 dates at 1.5 m below the lake surface. Temperature, dissolved oxygen concentration, and Secchi disk transparency were measured in situ, and pH was measured in the field. All other analyses were done at the Ministry of the Environment's laboratory in Toronto using methods described in MOE, 1975.

RESULTS

Appendices I-XX contain the results of the 1979 Nanticoke water chemistry monitoring program. These results are summarized in Table 1, which shows mean values by station, and Table 2, which shows mean values by date. Annual means (ice-free season) over all stations for six key parameters are shown in Table 3 for all 11 years of the Nanticoke study.

DISCUSSION

Water Quality Objectives

With the exception of one pH value (8.57) and one total iron value (0.31 mg/L), no parameter exceeded its Ontario Water Quality Objective for the protection of aquatic life (MOE, 1978).

Mean pH in the Nanticoke study area was 8.2 during the first 10 years of monitoring and it has not changed significantly since monitoring began (Weiler and Heathcote, 1979). A pH of 8.2 is close to the upper limit of the objective pH range of 6.5-8.5 specified by the MOE (1978). The single pH value outside this range in 1979 was likely owing to natural variability in pH or to sampling error. It cannot be considered significant.

The single total iron value exceeding the MOE (1978) water quality objective of 0.30 mg/L was statistically significantly different from the grand mean total iron concentration (by t-test; $p=0.05$). Without data from replicate samples, however, it is impossible to say whether this difference is real or caused by contamination, analytical error, or some other unknown cause.

Variation in Space and Time, 1979

Two-way analysis of variance (ANOVA) without replication was used to test whether variation in space and variation with time were statistically significant. Table 4 shows the results of this analysis. Eighty-nine percent of the parameters varied with time (95% significance level) and 42% of the parameters varied in space.

Variation in Space, 1969-1978

This is more variation in space than was reported in the past for Nanticoke water chemistry (Weiler and Heathcote, 1979). However, the authors of the Nanticoke water chemistry reports for the years 1973 to 1978 (Polak, 1975, 1977, 1978a and b; Polak and Kennedy, 1975; Heathcote, 1979) compared their calulated F-statistics with the wrong critical values of the F-distribution from statistical tables. In these reports, the critical values of the F-distribution for the degrees of freedom of the between-station and between-date variance terms were used to test the significance of between-station variance in ANOVA. The critical values of the F-distribution for the degrees of freedom of the between-station and error variance terms should have been used (Sokal and Rohlf, 1969). Comparing F-statistics calculated by ANOVA in the 1973 to 1978 reports with the correct critical values of the F-distribution showed that 17% of the between-station variances reported as not significant in the 1973 to 1978 reports were actually significant. No parameter varied significantly between stations every year, but specific conductance, turbidity, suspended solids, Secchi disk transparency, and total iron varied significantly between stations in most years. Twenty-seven percent of the between-station variances tested by ANOVA during the first 10 years of monitoring at Nanticoke were significantly different. Direct comparison of past results with 1979 results is difficult, however, because sampling stations, sampling depths, and parameters tested by ANOVA were not the same each year.

Applicability of ANOVA

To analyze these data using two-way ANOVA without replication, one must assume that the interaction between days and stations is not significant (Sokal and Rohlf, 1969) so all of the variance not attributable to differences between stations or differences between dates can be attributed to the error variance, or natural variability at a particular station and time. When one has data from replicate samples, one can calculate the error variance and test its statistical significance. Palmer (1968) did a two-way ANOVA with three replicates in each cell for dissolved oxygen, pH,

alkalinity, and total phosphate data from the Nanticoke stations. He found that the interaction terms were significant for dissolved oxygen, pH, and total phosphate. If this pattern has continued to the present, then the assumption underlying the use of two-way ANOVA without replication is not valid for these three parameters. Furthermore, this assumption might not be valid for parameters such as temperature, turbidity, suspended solids, and Secchi disk transparency that might be affected by storms, upwelling, and biological activity differently at different stations. Hence, there is reason to question the applicability of two-way ANOVA without replication as an analytical tool for these data. It would be advisable, therefore, to test the significance of the interaction terms on ANOVA for selected parameters by replicate sampling.

To study variation in space by a statistical method other than ANOVA, Weiler and Heathcote (1979) subjected to cluster analysis mean depth-averaged 1978 values for 12 water chemistry parameters from 13 Nanticoke stations and found that the stations were closely related. Euclidean distances (the square root of the sum of squares of differences in parameter levels between stations) ranged only between 2.0 to 6.9 on a scale of 0 to 100.

Palmer and Sato (1968) recommended the Kruskal-Wallis test, a non-parametric test, as the best method for determining whether there are significant differences between stations in a group. Testing between-station variability of 1979 Nanticoke data using this method confirmed the results of testing by two-way ANOVA for all but four parameters (Table 5). The different results obtained using the Kruskal-Wallis test should be accepted with caution, however, for ANOVA is generally more efficient at detecting departures from the null hypothesis even when the assumptions of ANOVA hold only approximately (Sokal and Rohlf, 1969).

Upwelling

The mean temperature over all five stations on 27 July 1979 was over $5^{o}C$ lower than the mean temperature just four days earlier and $4^{o}C$ lower than the mean temperature a month and a half later. Also, temperatures at the stations nearer shore were lower than the

temperature at the station farthest offshore. Upwelling of cooler bottom water likely caused this temperature distribution. Since Lake Erie bottom water tends to be depleted in dissolved oxygen in summer, the low dissolved oxygen percent saturations observed at the nearshore stations on 27 July support this suggestion. Similar rapid, temporary, nearshore temperature reductions are frequent at Nanticoke in the summer (Farooqui and Christensen, 1980).

CONCLUSIONS

1. In 1979, water quality at Nanticoke complied with Ontario water quality objectives for the protection of aquatic life.

2. In 1979, levels of about 90% of the water quality parameters studied at Nanticoke varied with the seasons and levels of about 40% of the parameters varied in space. This was slightly more than the 27% variation in space that was observed in the past at Nanticoke.

3. The distribution of temperature and dissolved oxygen percent concentration revealed that upwelling of bottom water was occurring on 27 July.

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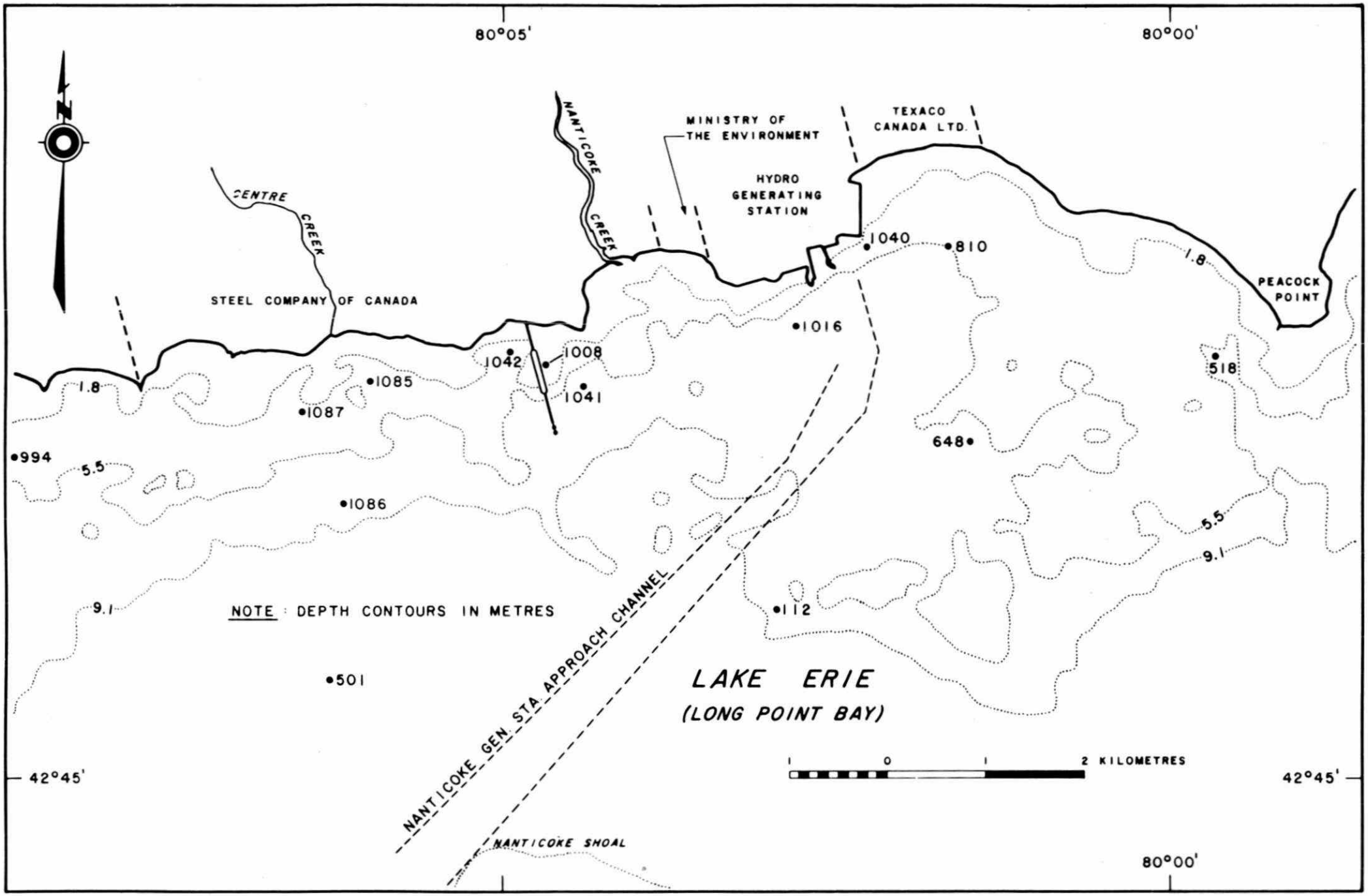

FIGURE 1 - NANTICOKE SAMPLING STATIONS SAMPLED IN 1979: 501, 810, 1040, 1085, 1087

TABLE 1: Summary of Results, Mean Value by Station, Nanticoke Water Chemistry, 1979

Station	Temp.	Spec. Cond.	Turb.	pH in situ	Cl^-	Total Alk as $CaCO_3$	React. Silicate as Si	Secchi disk	Diss. O_2	Diss. O_2	Total P	Filt. React. P	Total Kjeld N	Filt. $NO_2^- + NO_3^-$ N	Filt. NH_3 as N	Total N	Chlorophyll a	Chlorophyll b	Total Fe
	^oC	uS/cm	FTU	SU	mg/L	mg/L	mg/L	m	mg/L	% sat'n	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L
501	12.5	303	1.8	8.24	19.9	111	0.15	2.9	10.3	95	0.014	0.003	0.30	0.154	0.016	0.453	2.2	0.8	0.07
810	13.1	307	2.6	8.20	20.1	110	0.23	1.6	10.2	95	0.019	0.003	0.28	0.169	0.017	0.452	2.6	0.8	0.13
1040	14.0	309	2.7	8.15	20.1	111	0.16	1.2	10.2	97	0.028	0.004	0.30	0.180	0.019	0.475	2.8	0.8	0.17
1085	12.1	308	3.4	8.17	20.0	112	0.22	1.3	10.1	92	0.019	0.002	0.26	0.171	0.016	0.435	2.8	0.9	0.15
1086	12.3	307	2.8	8.20	20.0	110	0.26	1.9	10.1	93	0.014	0.002	0.26	0.159	0.014	0.416	2.8	0.9	0.12

TABLE 2: Summary of Results, Mean Value by Date, Nanticoke Water Chemistry, 1979

Date	Temp.	Spec. Cond.	Turb.	pH in situ	Cl^-	Total Alk as $CaCO_3$	React. Silicate as Si	Secchi disk	Diss. O_2	Diss. O_2	Total P	Filt. React. P	Total Kjeld N	Filt. $NO_2^- + NO_3^-$ as N	Filt. NH_3 as N	Total N	Chlorophyll a	Chlorophyll b	Total Fe
	^oC	uS/cm	FTU	SU	mg/L	mg/L	mg/L	m	mg/L	% sat'n	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L
2 May	7.6	311	3.0	-	20.0	98	0.05	1.4	11.8	98	0.014	0.002	0.24	0.185	0.008	0.423	4.0	1.2	0.19
4 May	7.6	312	3.4	-	20.0	109	0.06	1.4	11.7	98	0.032	0.004	0.33	0.196	0.016	0.530	4.4	1.5	0.20
25 Jun	14.1	307	1.2	8.34	20.7	111	0.09	2.1	11.1	107	0.039	0.002	0.41	0.178	0.033	0.590	1.9	1.6	0.07
27 Jun	15.6	308	2.1	8.33	20.4	110**	0.05	1.7	10.9	108	0.017	0.002	0.28	0.163	0.014	0.447	1.1	0.7	0.08
23 Jul	21.5	307*	3.5*	8.33*	20.1*	101*	0.10	1.8	9.1	102	0.016	0.002	0.25	0.125	0.011	0.379	1.2	0.4	0.12*
27 Jul	16.2	307	2.2	8.00	20.0	99	0.24	2.0	7.6	76	0.024	0.008	0.34	0.203	0.043	0.547	1.6	0.9	0.11
8 Sep	20.2	299	1.8	7.99	19.6	124	0.15	3.0	8.3	91	0.009	0.002	0.29	0.107	0.024	0.395	1.7	0.8	0.08
12 Sep	19.8	308	2.8	8.04	20.0	119	0.33	1.6	8.4	92	0.015	0.002	0.28	0.118	0.016	0.394	2.3	0.4	0.15
16 Oct	8.6	309	4.1	8.22	20.1	122	0.21	1.5	10.2	87	0.014	0.002	0.22	0.188	0.008	0.406	3.0	0.5	0.19
17 Oct	10.1	306	2.6	8.36	19.8	110	0.19	1.9	9.7	86	0.014	0.002	0.24	0.175	0.009	0.417	3.5	0.6	0.09
14 Nov	5.6	306	2.1	8.17	20.0	113	0.14	1.7	11.7	93	0.016	0.002	0.23	0.180	0.008	0.412	3.8	0.5	0.12
19 Nov	6.9	304	3.0	8.17	19.5	115	0.84	1.1	11.5	94	0.014	0.002	0.23	0.181	0.007	0.415	3.1	0.8	0.15

* 26 July

** 26 June

TABLE 3: Annual Means for Six Parameters, Nanticoke Water Chemistry

PARAMETER	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Specific Conductance (uS/cm)	325.6	323.0	312.7	322.6	312.7	308.7	298.4	301.5	304.4	293.1	307.0
Total Phosphorous (mg/L)	0.021	0.019	0.016	0.014	0.018	0.022	0.015	0.012	0.018	0.014	0.019
Total Nitrogen (mg/L)	0.356	0.434	0.354	0.363	0.412	0.445	0.393	0.427	0.382	0.514	0.446
Turbidity (FTU)	5.17	3.19	3.57	4.48	4.15	4.01	2.39	3.14	3.63	3.04	2.66
Diss. Oxygen (% Saturation)	96	97	101	-	-	-	94	93	106	97	94
Phytoplankton density (ASU/mL)	220	530	387	272	417	242	388	334	393	635	-

TABLE 4

Two-way Analysis of Variance, Nanticoke Water Chemistry, 1979

Parameter	Between-date F_s*	Between-date Significance**	Between-station F_s*	Between-station Significance**
Water Temperature	157.43	S.D.	6.91	S.D.
Specific Conductance	5.63	S.D.	6.01	S.D.
Turbidity	2.93	S.D.	3.41	S.D.
pH in situ	11.05	S.D.	1.15	N.S.D.
Chloride	10.94	S.D.	1.93	N.S.D.
Total Alkalinity	14.93	S.D.	0.43	N.S.D.
Reactive Silicate	10.62	S.D.	1.19	N.S.D.
Secchi Disk Transparency	1.79	N.S.D.	9.62	S.D.
Dissolved Oxygen	57.14	S.D.	0.35	N.S.D.
Dissolved Oxygen % Saturation	18.04	S.D.	1.75	N.S.D.
Total Phosphorous	1.46	N.S.D.	1.65	N.S.D.
Filtered Reactive Phosphorous	4.82	S.D.	3.38	S.D.
Total Kjeldahl Nitrogen	2.31	S.D.	0.59	N.S.D.
Filtered Nitrite + Nitrate	15.83	S.D.	3.87	S.D.
Filtered Ammonia	10.70	S.D.	0.67	N.S.D.
Total Nitrogen	3.61	S.D.	0.88	N.S.D.
Chlorophyll *a*	36.57	S.D.	3.67	S.D.
Chlorophyll *b*	21.33	S.D.	0.50	N.S.D.
Total Iron	3.69	S.D.	5.37	S.D.

* Calculated using a fixed-factor ANOVA with 12 sampling dates and five stations.

** Significance tested using a 5% one-tailed rejection region. For all parameters except pH, chlorophyll *b*, and total iron, $F_{0.05(11,44)} = 2.02$ was used to test significance of between-date variance and $F_{0.05(4,44)} = 2.59$ was used to test significance of between-station variance. In situ pH was

measured on only 10 dates, so $F_{0.05(9,36)} = 2.15$ and $F_{0.05(4,36)} = 2.64$ were used to test significance of between-date and between-station variance, respectively. Chlorophyll b was determined for only 11 dates and one missing value was estimated, so $F_{0.05(10,39)} = 2.09$ and $F_{0.05(4,39)} = 2.62$ were used to test significance of between-date and between-station variance, respectively. Total iron was determined for only 11 dates, so $F_{0.05(10,40)} = 2.08$ and $F_{0.05(4,40)} = 2.61$ were used to test significance of between-date and between-station variance, respectively.

S.D. means significant difference; N.S.D. means no significant difference.

TABLE 5

Kruskal-Wallis Test, Nanticoke Water Chemistry, 1979

Parameter	H/D*	Between-station significance**
Water Temperature	1.828	N.S.D.***
Specific Conductance	13.030	S.D.
Turbidity	10.361	S.D.
pH in situ	1.327	N.S.D.
Chloride	5.515	N.S.D.
Total Alkalinity	1.238	N.S.D.
Reactive Silicate	0.496	N.S.D.
Secchi Disk Transparency	22.105	S.D.
Dissolved Oxygen	0.108	N.S.D.
Dissolved Oxygen % Saturation	0.997	N.S.D.
Total Phosphorous	12.349	S.D.***
Filtered Reactive Phosphorous	10.360	S.D.
Total Kjeldahl Nitrogen	6.243	N.S.D.
Filtered Nitrite+Nitrate	0.997	N.S.D.***
Filtered Ammonia	2.573	N.S.D.
Total Nitrogen	5.788	N.S.D.
Chlorophyll *a*	1.839	N.S.D.***
Chlorophyll *b*	0.817	N.S.D.
Total Iron	15.892	S.D.

* Calculated using Kruskal-Wallis test with five stations.

** Tested using $\chi^2_{0.05(4)} = 9.488$. S.D. means significant difference; N.S.D. means no significant difference.

*** Different from result obtained by ANOVA (Table 4).

APPENDIX I: Nanticoke Water Temperature (^{o}C), 1979

(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	4.2	5.5	14.7	15.2	21.0	18.0	20.0	19.3	9.8	9.8	5.5	7.0	12.50	6.24
810	9.1	8.8	14.9	15.0	22.0	16.2	20.0	20.0	8.3	10.0	5.2	7.5	13.08	5.66
1040	10.4	8.5	13.6	17.0	22.0	16.1	20.8	20.0	10.7	12.5	7.8	9.0	14.03	5.04
1085	7.0	7.8	13.4	15.5	21.2	14.5	20.0	20.0	7.0	9.0	4.5	5.0	12.08	6.14
1087	7.1	7.5	13.8	15.5	21.3	16.0	20.0	19.5	7.2	9.0	5.0	6.2	12.34	6.00
Mean	7.56	7.62	14.08	15.64	21.50	16.16	20.16	19.76	8.60	10.06	5.60	6.94		
Std. Dev.	2.36	1.29	0.68	0.79	0.47	1.24	0.36	0.34	1.62	1.44	1.28	1.49		

Grand mean of individual measurements = 12.81; std. dev. = 5.67.

APPENDIX II: Nanticoke Specific Conductance (uS/cm), 1979

(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	305	305	306	306	305	305	290	306	305	302	305	300	303.3	4.6
810	317	310	308	308	310	306	302	310	305	302	306	305	307.4	4.1
1040	312	310	310	310	310	305	300	310	315	310	310	306	309.0	3.8
1085	308	320	306	306	305	310	302	307	312	308	306	307	308.1	4.5
1087	311	315	303	310	305	310	303	306	310	308	305	300	307.2	4.2
Mean	310.6	312.0	306.6	308.0	307.0	307.2	299.4	307.8	309.4	306.0	306.4	303.6		
Std. Dev.	4.5	5.7	2.6	2.0	2.7	2.6	5.4	2.0	4.4	3.7	2.1	3.4		

Grand mean of individual measurements = 307.0; std. dev. = 4.5.

APPENDIX III:

Nanticoke Turbidity (FTU), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	2.4	1.8	1.2	1.0	2.2	1.0	0.8	1.6	1.5	1.5	2.2	4.5	1.81	0.99
810	3.8	2.8	1.2	2.2	3.2	2.4	2.6	3.8	1.6	3.2	2.0	2.4	2.60	0.81
1040	3.2	2.6	1.2	2.5	2.2	2.6	2.6	3.0	5.2	2.8	2.2	2.8	2.74	0.92
1085	2.0	5.2	1.4	1.8	6.5	2.6	2.2	4.0	7.0	2.8	2.0	3.2	3.39	1.89
1087	3.6	4.6	1.2	3.2	3.6	2.2	0.72	1.8	5.2	2.6	2.2	2.2	2.76	1.33
Mean	3.00	3.40	1.24	2.14	3.54	2.16	1.78	2.84	4.10	2.58	2.12	3.02		
Std. Dev.	0.77	1.44	0.09	0.82	1.77	0.67	0.95	1.11	2.44	0.64	0.11	0.91		

Grand mean of individual measurements = 2.66; std. dev. = 1.31.

APPENDIX IV:

Nanticoke pH In Situ, 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	-	-	8.42	8.36	8.57	8.36	8.05	7.96	8.08	8.33	8.15	8.13	8.241	0.194
810	-	-	8.31	8.31	8.22	8.02	8.00	8.15	8.28	8.36	8.18	8.20	8.203	0.121
1040	-	-	8.34	8.27	8.15	7.84	8.01	8.00	8.25	8.34	8.20	8.14	8.154	0.162
1085	-	-	8.32	8.34	8.35	7.83	7.86	8.01	8.27	8.39	8.15	8.20	8.172	0.206
1087	-	-	8.30	8.36	8.38	7.94	8.05	8.06	8.20	8.37	8.16	8.16	8.198	0.153
Mean	-	-	8.338	8.328	8.334	7.998	7.994	8.036	8.216	8.358	8.168	8.166		
Std. Dev.	-	-	0.048	0.038	0.162	0.217	0.078	0.073	0.082	0.024	0.022	0.033		

Grand mean of individual measurements = 8.194; std. dev. = 0.165.

"-" means that the result is not available.

APPENDIX V:

Nanticoke Chloride (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	20.0	20	20.5	20.0	20.0	20.0	19.5	20.0	20.0	19.5	20.0	19.0	19.88	0.38
810	20.0	20	21.5	20.5	20.5	20.0	19.5	20.0	20.0	19.5	20.0	19.5	20.08	0.56
1040	20.0	20	20.5	20.5	20.0	20.0	19.5	20.0	20.5	20.0	20.0	20.0	20.08	0.29
1085	20.0	20	20.5	20.5	20.0	20.0	20.0	20.0	20.0	20.0	20.0	19.5	20.04	0.26
1087	20.0	20	20.5	20.5	20.0	20.0	19.5	20.0	20.0	20.0	20.0	19.5	20.00	0.30
Mean	20.00	20	20.70	20.40	20.10	20.00	19.60	20.00	20.10	19.80	20.00	19.50		
Std. Dev.	0	0	0.45	0.22	0.22	0	0.22	0	0.22	0.27	0	0.35		

Grand mean of individual measurements = 20.02; std. dev. = 0.37.

APPENDIX VI: Nanticoke Total Alkalinity as $CaCO_3$ (mg/L) 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	26 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	94	106	112	112	98	94	138	130	126	104	114	106	111.2	14.1
810	100	108	110	110	100	100	120	118	114	110	110	120	110.0	7.3
1040	98	104	108	108	100	100	120	120	132	114	112	118	111.2	10.2
1085	100	116	114	110	102	102	118	114	122	112	118	120	112.3	7.4
1087	96	112	112	110	104	100	126	114	116	112	110	110	110.2	7.7
Mean	97.6	109.2	111.2	110.0	100.8	99.2	124.4	119.2	122.0	110.4	112.8	114.8		
Std. Dev.	2.6	4.8	2.3	1.4	2.3	3.0	8.2	6.6	7.3	3.8	3.3	6.4		

Grand mean of individual measurements = 111.0; std. dev. = 9.4.

APPENDIX VII: Nanticoke Reactive Silicate (mg Si/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.05L	0.05	0.10	0.05	0.10	0.10	0.15	0.35	0.20	0.15	0.15	0.35	0.150D	0.104D
810	0.05	0.05	0.10	0.05	0.10	0.20	0.15	0.35	0.15	0.20	0.10	1.25	0.229	0.333
1040	0.05	0.05	0.10	0.05	0.10	0.25	0.15	0.25	0.25	0.20	0.15	0.35	0.162	0.098
1085	0.05L	0.10	0.10	0.05	0.10	0.35	0.15	0.35	0.25	0.20	0.10	0.80	0.217D	0.211D
1087	0.05	0.05	0.05	0.05	0.10	0.30	0.15	0.35	0.20	0.20	0.20	1.45	0.262	0.387
Mean	0.050D	0.060	0.090	0.050	0.100	0.240	0.150	0.330	0.210	0.190	0.140	0.840		
Std. Dev.	0D	0.022	0.022	0	0	0.096	0	0.045	0.042	0.022	0.042	0.505		

Grand mean of individual measurements = 0.204D; std. dev. = 0.250D.

"L" means that actual value is less than reported value.
"D" means that individual values with remark "L" were used in the computation.

APPENDIX VIII: Nanticoke Secchi Disk Transparency (m) 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	2.5	2.1	3.0	3.0	5.4	3.8	5.0	1.9	2.3	2.9	2.1	1.3	2.94	1.24
810	0.75	1.3	1.5	2.0	0.8	1.2	1.5	1.4	3.0	2.0	1.9	1.3	1.55	0.61
1040	1.0	1.7	1.1	1.0	1.0	1.7	1.5	1.2	1.0	1.2	1.2	1.0	1.22	0.27
1085	1.5	1.0	2.2	1.2	1.0	1.5	1.7	1.1	0.5	1.5	1.4	0.9	1.29	0.44
1087	1.5	1.0	2.5	1.5	1.0	2.0	5.2	2.3	0.9	2.0	1.7	1.0	1.88	1.18
Mean	1.45	1.42	2.06	1.74	1.84	2.04	2.98	1.58	1.54	1.92	1.66	1.10		
Std. Dev.	0.67	0.48	0.76	0.80	1.99	1.03	1.94	0.51	1.06	0.65	0.36	0.19		

Grand mean of individual measurements = 1.78; std. dev. = 1.03.

APPENDIX IX: Nanticoke Dissolved Oxygen (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	12.6	12.2	11.0	10.6	9.2	9.3	8.6	8.4	9.7	9.6	11.4	10.9	10.29	1.37
810	11.85	11.8	11.1	11.0	8.8	7.8	8.2	8.4	10.1	9.4	12.0	11.6	10.17	1.58
1040	11.65	12.1	11.4	10.9	8.8	6.8	8.3	8.3	10.2	9.6	11.9	11.8	10.15	1.76
1085	11.8	11.1	10.8	10.8	9.0	6.8	8.2	8.6	10.7	9.8	12.0	11.6	10.10	1.63
1087	11.2	11.3	11.0	11.0	9.6	7.2	8.4	8.5	10.2	10.2	11.4	11.4	10.12	1.41
Mean	11.82	11.70	11.06	10.86	9.08	7.58	8.34	8.44	10.18	9.72	11.74	11.46		
Std. Dev.	0.51	0.48	0.22	0.17	0.34	1.04	0.17	0.11	0.36	0.30	0.31	0.34		

Grand mean of individual measurements = 10.16; std. dev. = 1.50.

APPENDIX X: Nanticoke Dissolved Oxygen % Saturation, 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	96	97	108	105	102	97	94	90	85	84	90	90	94.8	7.5
810	102	101	109	108	100	79	89	92	86	83	94	97	95.0	9.6
1040	104	103	109	112	100	68	92	91	91	90	100	102	96.8	11.6
1085	97	93	103	107	100	66	89	94	88	85	93	91	92.2	10.4
1087	92	94	106	109	107	72	92	92	84	88	89	92	93.1	10.4
Mean	98.2	97.6	107.0	108.2	101.8	76.4	91.2	91.8	86.8	86.0	93.2	94.4		
Std. Dev.	4.8	4.3	2.6	2.6	3.0	12.5	2.2	1.5	2.8	2.9	4.3	5.0		

Grand mean of individual measurements = 94.4; std. dev. = 9.8.

APPENDIX XI: Nanticoke Total Phosphorus (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.014	0.029	0.016	0.013	0.010	0.020	0.006	0.010	0.009	0.011	0.011	0.017	0.0138	0.0061
810	0.014	0.031	0.019	0.017	0.018	0.044	0.012	0.020	0.009	0.012	0.015	0.012	0.0186	0.0098
1040	0.018	0.024	0.132	0.025	0.016	0.021	0.012	0.015	0.020	0.018	0.024	0.015	0.0283	0.0329
1085	0.012	0.060	0.015	0.016	0.018	0.018	0.009	0.017	0.018	0.017	0.017	0.014	0.0192	0.0131
1087	0.014	0.017	0.012	0.015	0.016	0.019	0.008	0.012	0.014	0.012	0.013	0.014	0.0138	0.0028
Mean	0.0144	0.0322	0.0388	0.0172	0.0156	0.0244	0.0094	0.0148	0.0140	0.0140	0.0160	0.0144		
Std. Dev.	0.0022	0.0165	0.0522	0.0046	0.0033	0.0110	0.0026	0.0040	0.0050	0.0032	0.0050	0.0018		

Grand mean of individual measurements = 0.0188; std. dev. = 0.0170.

APPENDIX XII: Nanticoke Filtered Reactive Phosphorus (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.003	0.002	0.004	0.003	0.002	0.008	0.002	0.001L	0.001	0.002	0.001	0.004	0.0028D	0.0020D
810	0.0025	0.004	0.003	0.001	0.004	0.011	0.001	0.002	0.002	0.002	0.002	0.001	0.0030	0.0027
1040	0.0025	0.009	0.002	0.003	0.003	0.007	0.003	0.002	0.005	0.004	0.005	0.001	0.0039	0.0023
1085	0.002	0.002	0.001	0.003	0.002	0.007	0.001	0.002	0.002	0.002	0.001	0.001	0.0022	0.0016
1087	0.001	0.002	0.001	0.001	0.001	0.005	0.002	0.001	0.002	0.002	0.001	0.002	0.0018	0.0011
Mean	0.0022	0.0038	0.0022	0.0022	0.0024	0.0076	0.0018	0.0016D	0.0024	0.0024	0.0020	0.0018		
Std. Dev.	0.0008	0.0030	0.0013	0.0011	0.0011	0.0022	0.0008	0.0005D	0.0015	0.0009	0.0017	0.0013		

Grand mean of individual measurements = 0.0027D; std. dev. = 0.0021D.

"L" means that actual value is less than reported value.
"D" means that individual values with remark "L" were used in the computation.

APPENDIX XIII: Nanticoke Total Kjeldahl Nitrogen (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.22	0.26	0.85	0.29	0.23	0.30	0.28	0.25	0.19	0.27	0.22	0.23	0.299	0.177
810	0.255	0.32	0.34	0.29	0.27	0.50	0.26	0.29	0.22	0.22	0.21	0.22	0.283	0.080
1040	0.265	0.52	0.32	0.29	0.24	0.35	0.31	0.28	0.23	0.24	0.24	0.26	0.295	0.080
1085	0.23	0.29	0.28	0.28	0.26	0.27	0.31	0.27	0.23	0.24	0.26	0.25	0.264	0.024
1087	0.22	0.28	0.27	0.27	0.27	0.30	0.28	0.29	0.22	0.24	0.23	0.21	0.257	0.031
Mean	0.238	0.334	0.412	0.284	0.254	0.344	0.288	0.276	0.218	0.242	0.232	0.234		
Std. Dev.	0.021	0.106	0.247	0.009	0.018	0.092	0.022	0.017	0.016	0.018	0.019	0.021		

Grand mean of individual measurements = 0.280; std. dev. = 0.094.

APPENDIX XIV: Nanticoke Filtered $NO_2^- + NO_3^-$ as N (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.200	0.180	0.135	0.135	0.115	0.155	0.115	0.120	0.173	0.170	0.165	0.180	0.1536	0.0288
810	0.190	0.190	0.225	0.170	0.145	0.210	0.105	0.135	0.158	0.160	0.165	0.180	0.1694	0.0328
1040	0.195	0.185	0.185	0.190	0.145	0.235	0.095	0.115	0.216	0.180	0.210	0.205	0.1797	0.0414
1085	0.165	0.225	0.175	0.165	0.115	0.225	0.110	0.120	0.206	0.185	0.190	0.170	0.1709	0.0395
1087	0.175	0.200	0.170	0.155	0.105	0.190	0.110	0.100	0.187	0.180	0.170	0.170	0.1593	0.0348
Mean	0.1850	0.1960	0.1780	0.1630	0.1250	0.2030	0.1070	0.1180	0.1880	0.1750	0.1800	0.1810		
Std. Dev.	0.0146	0.0178	0.0323	0.0202	0.0187	0.0317	0.0076	0.0125	0.0236	0.0100	0.0197	0.0143		

Grand mean of individual measurements = 0.1666; std. dev. = 0.0357.

APPENDIX XV: Nanticoke Filtered Ammonia as N (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.008	0.006	0.059	0.015	0.008	0.026	0.022	0.014	0.004	0.011	0.006	0.016	0.0162	0.0150
810	0.009	0.018	0.036	0.012	0.016	0.038	0.020	0.028	0.008	0.006	0.012	0.004	0.0172	0.0114
1040	0.0085	0.036	0.022	0.018	0.021	0.046	0.028	0.010	0.010	0.010	0.010	0.008	0.0190	0.0123
1085	0.008	0.014	0.024	0.014	0.005	0.056	0.028	0.014	0.010	0.008	0.008	0.005	0.0162	0.0144
1087	0.008	0.008	0.022	0.012	0.004	0.049	0.022	0.014	0.006	0.012	0.006	0.004	0.0139	0.0127
Mean	0.0083	0.0164	0.0326	0.0142	0.0108	0.0430	0.0240	0.0160	0.0076	0.0094	0.0084	0.0074		
Std. Dev.	0.0004	0.0119	0.0159	0.0025	0.0074	0.0115	0.0037	0.0069	0.0026	0.0024	0.0026	0.0051		

Grand mean of individual measurements = 0.0165; std. dev. = 0.0129.

APPENDIX XVI: Nanticoke Total Nitrogen (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.420	0.440	0.985	0.425	0.345	0.455	0.395	0.370	0.363	0.440	0.385	0.410	0.4528	0.1710
810	0.445	0.510	0.565	0.460	0.415	0.710	0.365	0.425	0.378	0.380	0.375	0.400	0.4523	0.1008
1040	0.460	0.705	0.505	0.480	0.385	0.585	0.405	0.395	0.446	0.420	0.450	0.465	0.4751	0.0905
1085	0.395	0.515	0.455	0.445	0.375	0.495	0.420	0.390	0.436	0.425	0.450	0.420	0.4351	0.0410
1087	0.395	0.480	0.440	0.425	0.375	0.490	0.390	0.390	0.407	0.420	0.400	0.380	0.4160	0.0374
Mean	0.4230	0.5300	0.5900	0.4470	0.3790	0.5470	0.3950	0.3940	0.4060	0.4170	0.4120	0.4150		
Std. Dev.	0.0293	0.1023	0.2262	0.0236	0.0251	0.1030	0.0203	0.0198	0.0358	0.0222	0.0358	0.0316		

Grand mean of individual measurements = 0.4462; std. dev. = 0.0992.

APPENDIX XVII: Nanticoke Chlorophyll *a* (ug/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	3.2	4.0	0.9	1.0	1.0	1.4	1.4	1.8	2.6	3.8	3.7	2.1	2.24	1.18
810	4.2	4.0	2.2	0.7	1.2	1.8	1.7	2.4	2.8	3.3	4.0	3.2	2.62	1.15
1040	5.2	4.2	2.2	0.8	1.2	1.2	1.9	2.4	3.7	3.8	3.6	3.7	2.82	1.40
1085	3.7	5.7	1.8	1.7	1.2	1.4	1.7	2.7	3.2	3.1	3.7	3.1	2.75	1.29
1087	3.9	4.2	2.2	1.4	1.5	2.3	1.6	2.4	2.9	3.3	3.9	3.6	2.77	1.01
Mean	4.04	4.42	1.86	1.12	1.22	1.62	1.66	2.34	3.04	3.46	3.78	3.14		
Std. Dev.	0.74	0.72	0.56	0.42	0.18	0.44	0.18	0.33	0.43	0.32	0.16	0.63		

Grand mean of individual measurements = 2.64; std. dev. = 1.19.

APPENDIX XVIII: Nanticoke Chlorophyll b (ug/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	23 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	1.0	1.5	-	-	0.9	0.2	1.1	0.6	0.6	0.7	0.5	0.5	0.76	0.37
810	1.65	1.2	1.7	-	0.7	0.5	0.8	0.8	0.3	0.2	0.4	0.6	0.80	0.51
1040	1.0	1.3	1.7	-	0.6	0.4	0.8	0.9	0.4	0.4	0.6	0.4	0.77	0.43
1085	1.4	2.2	1.4	-	0.6	0.3	0.9	0.7	0.5	0.5	0.7	0.4	0.87	0.57
1087	1.0	1.5	1.7	-	0.7	0.6	0.9	0.9	0.3	0.8	0.7	0.5	0.87	0.41
Mean	1.21	1.54	1.62		0.70	0.40	0.90	0.78	0.42	0.52	0.58	0.48		
Std. Dev.	0.30	0.39	0.15		0.12	0.16	0.12	0.13	0.13	0.24	0.13	0.08		

Grand mean of individual measurements = 0.82; std. dev. = 0.45.

"-" means that the result is not available.

APPENDIX XIX:

Nanticoke Total Iron (mg/L), 1979
(Depth = 1.5 m)

Station	2 May	4 May	25 Jun	27 Jun	26 Jul	27 Jul	8 Sep	12 Sep	16 Oct	17 Oct	14 Nov	19 Nov	Mean	Std. Dev.
501	0.09	0.09	0.04	0.02	-	0.04	0.02	0.08	0.07	0.05	0.09	0.18	0.070	0.045
810	0.235	0.20	0.09	0.04	-	0.13	0.13	0.25	0.06	0.05	0.08	0.15	0.129	0.074
1040	0.275	0.19	0.11	0.22	0.12	0.14	0.14	0.13	0.26	0.12	0.21	0.14	0.171	0.058
1085	0.11	0.26	0.04	0.07	-	0.14	0.11	0.19	0.31	0.11	0.13	0.16	0.148	0.079
1087	0.25	0.25	0.08	0.03	-	0.09	0.02	0.10	0.23	0.11	0.10	0.10	0.124	0.082
Mean	0.192	0.198	0.072	0.076	0.12	0.108	0.084	0.150	0.186	0.088	0.122	0.146		
Std. Dev.	0.085	0.067	0.031	0.0826	-	0.043	0.059	0.070	0.114	0.035	0.053	0.030		

Grand mean of individual measurements = 0.129; std. dev. = 0.075.

"-" means that the result is not available.

APPENDIX XX: Nanticoke Additional Parameters (ug/L), 1979
(Depth = 1.5 m)

	2 May	4 May	25 Jun	27 Jun	26 Jul	12 Sep	17 Oct	14 Nov
Total Cadmium								
Station 501	0.005L	-	0.005L	-	0.005L	0.005L	0.005L	0.007
810,1085,1087	0.005L	-	0.005L	-	0.005L	0.005L	0.005L	0.005L
1040	0.005L	-	0.005L	-	0.005L	0.005L	0.005L	0.008
Total Chromium								
Station 501,1087	0.02L	-	0.02L	-	0.02	0.02L	0.02L	0.02L
810,1040	0.02L	-	0.02L	-	0.02L	0.02L	0.02L	0.02L
1085	0.02L	-	0.02L	-	0.03	0.02L	0.02L	0.02L
Total Copper								
Station 501	0.01L	-	0.02	-	0.01L	0.01L	0.01L	0.01L
810,1040,1087	0.02	-	0.02	-	0.01L	0.01L	0.01L	0.01L
1085	0.01	-	0.02	-	0.02	0.01L	0.01L	0.01L
Total Lead								
Station 501	0.03L	-	0.04L	-	0.03L	0.03L	0.08	0.03L
810,1040,1085, 1087	0.03L	-	0.04L	-	0.03L	0.03L	0.03L	0.03L

APPENDIX XX: (CONT'D)

	2 May	4 May	25 Jun	27 Jun	26 Jul	12 Sep	17 Oct	14 Nov
Total Mercury								
Station 501	0.02L	-	0.02L	-	0.03	-	-	-
810	0.03	-	0.02L	-	0.04	-	-	-
1040	0.09	-	0.02L	-	0.04	-	-	-
1085	0.03	-	0.02L	-	0.06	-	-	-
1087	0.02	-	0.02L	-	0.20	-	-	-
Total Nickel								
Station 501	0.02L	-	0.02L	-	0.02	0.02L	0.03	0.02L
810,1040	0.02L	-	0.02L	-	0.04	0.02L	0.02L	0.02L
1085	0.02L	-	0.02L	-	0.02L	0.02L	0.02L	0.02L
1087	0.02L	-	0.02L	-	0.02L	0.02L	0.02	0.02L
Total Zinc								
Station 501	0.01L	-	0.01	-	0.01L	0.01L	0.04	0.01L
810	0.03	-	0.01L	-	0.01L	0.01L	0.01L	0.04
1040	0.02	-	0.01L	-	0.01L	0.01L	0.01L	0.06
1085	0.01L	-	0.01L	-	0.01L	0.01L	0.01L	0.02
1087	0.02	-	0.01L	-	0.02	0.01L	0.01L	0.01L
Phenols								
Station 501,810,1040, 1085,1087	1L	1L	1L	1L	1L	1L	1L	1L

"-" means that the result is not available.

"L" means that the actual value is less than the reported value.

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